

## Termite Control Studies in Panama

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### SUMMARY

Subterranean termite control studies in a tropic area (Panama) are described. Testing was first started in 1943 on Barro Colorado Island, which was formed when the Panama Canal was completed in the early 1900's.

Materials tested included DDT (various concentrations and formulations), BHC, trichlorobenzene, sodium arsenite, pentachlorophenol, sodium fluosilicate, copper ammonium fluoride, aldrin, chlordane, dieldrin, and heptachlor. Dieldrin (1.0 percent), applied to the soil as a water emulsion, was still 100 percent effective after 27 years when the tests were terminated. Tests with aldrin, chlordane, and heptachlor were initiated in 1963 and all three chemicals were still 100 percent effective after 16 years.<sup>1</sup>

**Additional keywords:** Field studies, soil treatments, test procedures, tropics.

### INTRODUCTION

Since construction of the Panama Canal in the early 1900's, subterranean termites have interfered with canal operations by damaging its facilities. Nearby military installations have also suffered severe damage. To deter-

mine the effectiveness of treating the soil for the prevention of termite damage and to evaluate many soil treatment chemicals in a tropical environment, a series of long-term field evaluations were conducted. Tests began in 1943 on Barro Colorado Island, Panama where additional tests were installed in 1946. The island, formed by canal construction, is about 18 miles from the Atlantic outlet in the Canal, and since 1924 has been under the jurisdiction of the Smithsonian Institute. During 1951-53, termite control studies were considerably expanded in an area known as the Curundu Jungle Test Site at Fort Clayton on the Pacific side of the isthmus. In 1963, more tests were installed on an adjacent jungle site.

The early work began when our Forest Insect Laboratory was part of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, with funding stimulated by information requests from the United States War and Navy Departments.

All these tests were closed in 1979 when jurisdiction of the test areas reverted to the Republic of Panama.

Although many of the test chemicals did not perform well enough to be recommended for termite control, significant results from all tests are reported and discussed to provide a basis of comparison for results from future tests in tropical environments.

### MATERIALS AND METHODS

Although the procedural details varied slightly from test to test and were modified and improved with experience, essentially 2 standard field test procedures were used to evaluate the effectiveness of various chemical treatments.

#### Standard Test Methods

The first standard method, the stake test (fig. 1), consisted of digging a hole 38 cm in diameter and 48 cm deep, removing approximately 0.057 m<sup>3</sup> of soil, and then

<sup>1</sup>This publication reports research involving insecticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and Federal agencies before they can be recommended.

**CAUTION:** Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

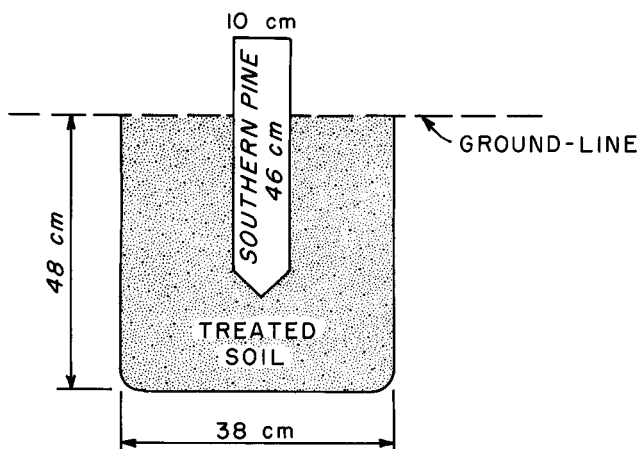


Figure 1.—Stake test method for evaluating insecticides.

treating the soil before it was replaced. A wooden stake, 5 × 10 × 46 cm, was driven to a depth of 31 cm in the center of this treated soil to serve as bait (food) for the termites. This bait stake was either southern pine or some other termite susceptible wood and served as an indicator at the annual inspections to determine if termites had successfully penetrated the treated soil around the stake. Each treatment was placed a minimum of 1.5 m away from another treatment. Each concentration of each chemical was replicated 10 times in a randomized complete block. When termites had penetrated the soil in 5 of the 10 replicates, the treatment was considered a failure.

The 1943 Barro Colorado stake tests were the first replicated termite studies installed under tropical conditions in which 39 different treatments were applied.

Treatments included sodium arsenite as a dry powder and as a 10 percent solution in water; creosote in various oils; 5 percent pentachlorophenol; orthodichlorobenzene in oil, in creosote, and in creosote plus diesel oil; and diesel oil controls.

The 1946 Barro Colorado stake tests included different dosages of 16 chemicals and methods for a total of 54 treatments. Dosages were 1.69, 3.38, and 6.76 liter/m<sup>3</sup> of soil for plots with the standard 38 cm diameter × 48-cm deep hole (0.057 m<sup>3</sup>). Some of the more recognizable formulations included 5.0 percent DDT in water; 5.0 percent DDT in acetylenetetrachloride; 0.8 percent benzene hexachloride (BHC) in kerosene; copper naphthanate (2 percent copper in kerosene); lead arsenate, dry powder at 227-g dosage and in water, 227 g in 0.94 liter at a 0.94-liter dosage only; 5 percent monochloronaphthalene in kerosene; kerosene controls; and untreated controls.

A new series of standardized stake tests was installed at Curundu in a new test area in 1952–53. The 1952 group included the following emulsions and fuel oil solutions:

- 5.0 percent DDT in oil
- 5.0 percent DDT plus 2.0 percent chlordane in oil.
- 20.0 percent DDT in Xylene.
- 0.50, 1.0, and 2.0 percent dieldrin in water.
- 0.4 percent gamma BHC in oil.
- Trichlorobenzene in diesel oil (3 to 1 ratio).
- Untreated controls—both oil and water.

Dosages were 6.76 and 10.1 liters/m<sup>3</sup> for the emulsions and oils and 0.94 and 1.88 liters for the DDT concentrate.

The second standard method, the ground-board test (fig. 2), was designed to protect wooden military equipment laid on the jungle floor. However, it is also a good method for evaluating materials used underneath slab-type house construction. The method consisted of removing the duff and debris from a 43-cm<sup>2</sup> area of soil in order to expose the mineral soil. The material to be evaluated was then sprinkled on the soil surface and a wooden pine board 30 × 30 × 2.5 cm was placed in the center of the treated area. A rock or brick was then laid on the board to hold it in place. The board was examined annually for the presence of damage by termites, which, if found, would indicate that termites had successfully penetrated the treated soil. Ten replicates of the test variables were also used in this method and randomization was complete within blocks. Again, when termites had penetrated 5 of the 10 replicates, the treatment was considered a failure.

In 1946, a series of ground-board treatments were established on Barro Colorado Island to determine not only the chemical effectiveness in controlling termites but also to make comparisons with the earlier described stake test method. A set of 10 sample replicates were installed on tilled and 10 on untilled soil in this heavily shaded jungle area. The 43 treatments included 3 dosages each of 13 chemical formulations and 4 untreated controls. The formulations consisted of the following:

- Acetylenetetrachloride.
- 5.0 percent DDT in diesel oil.

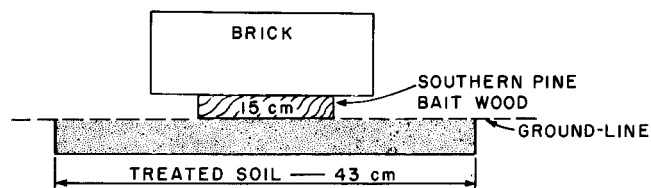


Figure 2.—Standard ground-board method for evaluating insecticides.

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the soil surface. Forty-eight separate treatments which included chlordane and dieldrin at 0.03, 0.06, 0.12, 0.25, 0.50, 1.0, and 2.0 percent; and aldrin and heptachlor at 0.06 and 0.25 percent were installed at 946 and 1892 ml/929 cm<sup>2</sup>. Aldrin, dieldrin, and heptachlor granules were applied to the soil to give equivalencies of 0.12, 0.25, 0.50, and 1.0 percent applied at the rate of 10.12 liters/m<sup>2</sup>. Chlordane granules were applied at only 0.25 and 0.50 percent.

## RESULTS AND DISCUSSION

### Barro Colorado—1943—Stake Tests

By 1952 (9 years), all treatments except those which included sodium arsenite had failed to prevent termites from attacking wood bait stakes. At the time the test was concluded in 1954, the arsenite treatments 810, 1620, and 2430 g/m<sup>3</sup> of dry chemical and 4.73 ml of 10 percent solution in water/m<sup>3</sup> were providing termite protection under the severe tropical exposure.

### Barro Colorado—1946—Stake Tests

By 1952 (6 years), all treatments except 2 DDT formulations, 2 BHC, 4 monochloronaphthalene, 4 copper naphthanate, and 1 lead arsenate had failed to prevent

termite attack. The 1954 (8-year) inspection showed that only the 8.0 percent DDT in acetylenetetrachloride treatment still had limited effectiveness. In the DDT treatment, soil in only 6 of the 10 replicates was not penetrated by termites—60 percent protection.

### Barro Colorado—1946—Ground-board Tests

When the test was closed in 1954 (8 years), only 2 formulations continued to provide control: 5.0 percent DDT in diesel oil and 10 percent sodium arsenite in water. They were giving 80 percent protection, which, by today's standards, would not be acceptable for recommendation as subterranean termite control. The results of the new technique were so similar to the "stake test" (a more difficult and time-consuming study to install) that it has been the test technique used in subsequent studies.

### Curundu—1952–53—Stake Tests

BHC was less effective than DDT, chlordane, or dieldrin, and of the latter 3, DDT was the least effective (table 1). For example, in soil treated with BHC, attacks first showed up at the end of the fifth year. By the end of the ninth year, there were multiple attacks through the treated soil. The recorded attacks to the highest treatments of dieldrin and chlordane during the second and third years of the test may have been anomalies because little or no further attacks occurred to these treatments.

Table 2.—Evaluation of insecticides applied as soil treatments in ground-board tests in 1953 in the Panama Canal Zone

Treatment designation and material	Rate of application liters/m <sup>2</sup>	% of ground boards undamaged by termites after exposure for indicated years															
		1	2	3	4	5	6	8	10	12	14	16	18	20	22	24	26
Richfield Oil Co.																	
#1 Lavacide Oil	5.06	100	50	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Same as above plus 5% penta.	5.06	90	50	40	....	....	....	....	....	....	....	....	....	....	....	....	....
Same as above plus 2% copper naphthanate	5.06	90	50	50	....	....	....	....	....	....	....	....	....	....	....	....	....
Richfield Oil Co.																	
#4 Weedkiller "A"	5.06	100	70	60	60	50	....	....	....	....	....	....	....	....	....	....	....
Same as above plus 5% penta	5.06	90	50	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Same as above plus 2% copper naphthanate	5.06	90	60	50	....	....	....	....	....	....	....	....	....	....	....	....	....
1.0% Dieldrin in water	5.06	100	100	100	100	100	100	100	100	100	89	89	89	89	89	75	75
1.0% Dieldrin in water	7.59	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2.0% Dieldrin in water	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2.0% Dieldrin in water	7.59	100	100	100	100	100	100	100	100	89	89	89	89	89	89	89	89
0.5% Dieldrin in fuel oil	2.53	100	100	100	100	100	100	100	100	100	90	90	90	70	50 <sup>1</sup>	....	....
0.5% Dieldrin in fuel oil	5.06	100	100	100	100	100	100	100	100	100	100	80	80	80	30 <sup>1</sup>	....	....
1.0% Dieldrin in fuel oil	2.53	100	100	100	100	100	100	100	90	90	90	90	80	80	50 <sup>1</sup>	....	....
1.0% Dieldrin in fuel oil	5.06	100	100	100	100	100	100	80	80	80	80	80	80	70 <sup>1</sup>	70	70	70
2.0% Dieldrin in fuel oil	2.53	100	100	100	100	100	100	100	100	100	100	100	100	100	100	75 <sup>1</sup>	75 <sup>1</sup>
2.0% Dieldrin in fuel oil	5.06	100	100	100	100	100	100	100	100	100	100	100	100	89	89	89	89
Untreated control	.....	50	60	50	70	50	50	40	50	50	70	70	30	20	40	40	40 <sup>1</sup>

<sup>1</sup>These attacks were made by *Heterotermes* sp.

## Curundu—1951–53—Ground-board Tests

Dieldrin was the only true insecticide evaluated in the ground-board test in studies installed in 1951–53 (table 2). The other chemicals, mostly different oils, did not prevent termite attack. Only a Richfield Oil Company<sup>2</sup> weed killer gave 50 percent control for more than 4 years. Dieldrin at both 0.5 percent and 1.0 percent at 5.06 liters/m<sup>2</sup> of soil surface area failed (less than 50 percent effective) at 22 years. Even though this is excellent long-term

<sup>2</sup>Mention of a company trade name does not necessarily imply endorsement by the U.S. Department of Agriculture.

protection, it did not give protection as long as dieldrin installed in tests in Mississippi. The only treatments which remained 100 percent effective for the entire 26 years was 1.0 percent dieldrin at 15.18 liters/m<sup>2</sup> and 2.0 percent dieldrin at 10.12 liters/m<sup>2</sup>. The 2.0 and 1.0 percent dieldrin in fuel oil gave excellent protection but sustained some attacks after 26 years and 20 years, respectively. Since oil is no longer used as a carrier for termiticides except in special cases, these formulations are not suggested for use. Results of this test particularly apply to *Heterotermes convexinotatus* (Snyder) and *Heterotermes tenuis* (Hagen) because these were the predominant species found in the study areas.

Table 3.—Insecticides evaluated against subterranean termites (*Coptotermes* sp. and *Heterotermes* sp.) in the Panama Canal Zone in 1963

Formulation (approx. % by wt.)	Rate of application liters/m <sup>2</sup>	% of ground boards undamaged by termites after exposure for indicated years															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Aldrin (actual)																	
0.067	5.06	100	100	100	100	100	100	100	100	90	80	80	70	60	60	30	....
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	90	70	70	60
0.25	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Dieldrin (actual)																	
0.033	5.06	100	100	100	90	90	90	80	70	50	....	....	....	....	....	....	....
	10.12	100	100	90	90	80	80	80	80	50	....	....	....	....	....	....	....
0.067	5.06	100	100	100	90	90	90	90	80	60	50	....	....	....	....	....	....
	10.12	100	100	100	100	100	100	90	80	80	50	....	....	....	....	....	....
0.125	5.06	100	100	100	100	100	100	100	100	100	90	70	50	....	....	....	....
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	70	60	60	60
0.25	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	90
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.50	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.0	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Heptachlor (actual)																	
0.067	5.06	100	100	100	100	100	100	100	100	100	100	90	70	60	....	....	....
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	80	80	50	....
0.25	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	90
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Chlordane (technical)																	
0.033	5.06	100	100	100	80	70	60	60	60	50	....	....	....	....	....	....	....
	10.12	100	100	100	70	70	70	40	....	....	....	....	....	....	....	....	....
0.067	5.06	100	90	90	90	80	80	80	70	40	....	....	....	....	....	....	....
	10.12	100	100	100	100	100	90	90	80	70	70	50	....	....	....	....	....
0.125	5.06	100	100	100	100	100	100	90	90	80	80	70	50	....	....	....	....
	10.12	100	100	100	100	100	90	90	80	80	80	70	50	....	....	....	....
0.25	5.06	100	100	100	100	100	100	100	100	90	60	60	40	....	....	....	....
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5	5.06	100	100	100	100	100	100	100	100	100	90	80	80	80	80	80	80
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.0	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	10.12	100	100	100	100	100	100	100	100	90	90	90	90	90	90	90	90
2.0	5.06	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	10.12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Untreated control	0	50	50	70	40	60	50	40	50	10	0	10	0	0	40	10	10

## Ground-board Series—1963

Aldrin- and heptachlor-treated soils were not penetrated by termites until the ninth and eleventh years, respectively, when the 0.067 percent treatment of each chemical sustained 1 penetration. By the thirteenth and fifteenth year, respectively, they were both considered failures because the bait wood had been attacked in over 50 percent of the replicates (table 3).

Chlordane and dieldrin, when applied at 0.067 percent, were attacked by the second and fourth year, respectively, with total failure occurring at the ninth and tenth year, respectively. Treatments with solutions higher than 0.067 percent were effective much longer; dosages higher than 0.25 percent were still 100 percent effective when the tests were terminated.

Table 4 presents the results of the granular insecticides applied directly to the soil. Only 5 treatments, 0.50 percent and 1.0 percent aldrin, 0.50 percent and 1.0 percent dieldrin, and 1.0 percent heptachlor remained 100 percent effective for the duration (16 years) of the study. The earliest attack was found on 0.125 percent and 0.25 percent heptachlor, which occurred during the fifth annual inspection. Generally, these granular treatments did not perform as well as the emulsions, but this was expected because the granular materials were more subject to washing by rainfall than the emulsions.

The species of termites penetrating the soil (either *Coptotermes* sp. or *Heterotermes* sp.) were recorded, but in many cases, the wooden monitoring baits were totally destroyed and no termites were present. Based on the termites that could be identified, the predominant termites in the study areas were *Coptotermes niger* Snyder, *H. convexinotatus* and *H. tenuis*. *Nasutitermes corniger* Motsch. and *Microcerotermes arboreus* Emerson were also found in the area.

## RECOMMENDATIONS

1. Aldrin is the best material to use based on the fact that no attacks occurred on any soil treated with 0.25 percent solution or higher.

2. Heptachlor and dieldrin appear equal in effectiveness because both were 90 percent effective at 0.25 percent after 16 years, but it is suggested that heptachlor be favored over dieldrin since 0.067 percent dieldrin was attacked earlier than 0.067 heptachlor.

3. All granular materials at 0.50 percent appear approximately equal in effectiveness, however, since no-use labels are available for granules, they are not recommended for use at this time.

Table 4.—Granular insecticides applied in ground-board tests in 1963 in the Panama Canal Zone

Formulation (approx. % by weight)	Weight of toxicant applied <sup>1</sup> (g/932 cm <sup>2</sup> )	% of ground boards undamaged by termites after indicated years															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Aldrin (actual)																	
0.125	1.19	100	100	100	100	100	90	90	90	90	90	90	80	70	70	30	....
0.25	2.37	100	100	100	100	100	100	100	100	100	100	100	100	90	90	90	80
0.50	4.73	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.0	9.46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Dieldrin (actual)																	
0.125	1.19	100	100	100	100	100	100	100	100	100	100	90	80	80	80	80	70
0.25	2.37	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	90
0.50	4.73	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1.0	9.46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Chlordane (technical)																	
0.25	2.37	100	100	100	100	100	100	100	100	80	80	80	50	....	....	....	....
0.50	4.73	100	100	100	100	100	100	100	100	100	100	100	100	100	90	90	90
Heptachlor (actual)																	
0.125	1.19	100	100	100	100	90	90	90	90	80	80	70	60	60	40	....	....
0.25	2.37	100	100	100	100	90	90	90	90	90	80	80	70	60	50	....	....
0.50	4.73	100	100	100	90	90	90	90	90	90	90	90	90	90	90	90	90
1.0	9.46	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Untreated control	.....	50	50	70	40	60	50	40	50	10	0	10	0	0	40	10	10

<sup>1</sup>The amounts shown in this column are equivalent to amounts of toxicant that are applied for each percentage of 946 ml/932 cm<sup>2</sup> in water emulsion.